2005

Revised land freight external costs in Australia

Philip Laird
University of Wollongong, plaird@uow.edu.au

Revised land freight external costs in Australia

Abstract

Publications in Australia to 1999 that comment on transport externalities include the former Inter-State Commission (ISC - 1990), the National Transport Planning Taskforce (NTPT - 1994) Victorian Environment Protection Authority (1994), Simpson and London (1995), Manins (1997), Brindle et al (1999), and the Bureau of Transport Economics (BTE - 1999). As noted by the ISC (1990, p89), road external costs are "…costs imposed outside market transactions and they fall on a number of individuals or groups - road users other than those individuals who give rise to the costs, individuals other than road users (such as those who live in proximity to roads), or society as a whole." The ISC (loc.cit.) notes some external costs associated with road use as including "crash costs, congestion costs, noise pollution costs, and atmospheric pollution costs." Such external costs may also be imposed by rail freight. The NTPT (1994, p53) noted, inter alia "...A pricing mechanism for road use, which relates use to cost of provision and external costs, such as congestion and environmental factors, needs to be developed. Similarly, pricing mechanisms linking use of port, airport and rail infrastructure to the costs of provision, are required."

Disciplines

Physical Sciences and Mathematics

Publication Details

This conference paper was originally publsiehd as Laird, PG, Revised land freight external costs in Australia, in Raimond, T (ed), Proceedings of the Australasian Transport Research Forum, NSW Government Planning: Sydney, 2005, 1-12.

Revised Land Freight External Costs In Australia

Philip Laird, University of Wollongong

1 Introduction

Publications in Australia to 1999 that comment on transport externalities include the former Inter-State Commission (ISC - 1990), the National Transport Planning Taskforce (NTPT - 1994) Victorian Environment Protection Authority (1994), Simpson and London (1995), Manins (1997), Brindle et al (1999), and the Bureau of Transport Economics (BTE - 1999). As noted by the ISC (1990, p89), road external costs are *"…costs imposed outside market transactions and they fall on a number of individuals or groups - road users other than those individuals who give rise to the costs, individuals other than road users (such as those who live in proximity to roads), or society as a whole."* The ISC (loc.cit.) notes some external costs associated with road use as including *"crash costs, congestion costs, noise pollution costs, and atmospheric pollution costs."* Such external costs may also be imposed by rail freight. The NTPT (1994, p53) noted, inter alia *"...A pricing mechanism for road use, which relates use to cost of provision and external costs, such as congestion and environmental factors, needs to be developed. Similarly, pricing mechanisms linking use of port, airport and rail infrastructure to the costs of provision, are required."*

For a given environmental or social impact from road freight, there is a question of how much can be regarded as an external cost, as opposed to some costs being internalised by either by the road freight industry, or road users as a whole. There is also a similar question as to the use of external benefits, which have long been used in the evaluation of benefit-cost ratios for major road projects. By way of example, Abelson (1986) recognises Vehicle Operating Costs (including a NIMPAC model), the value of travel time savings, road accident costs, and environmental benefits (which may be offset by other environmental costs). Such external benefits are also discussed in the Austroads 1996 Benefit Cost Manual. Favourable travel time savings can result in a high Benefit Cost Ratio (BCR) for a road project.

Many reports since 1999 citing estimates of external costs of land freight transport in Australia refer to the BTE (1999) report. Along with reviewing recent trends for interstate non-bulk freight and the effect of the then proposed Commonwealth New Tax System (NTS), this report also gave road and rail freight costs and externalities, in cents per net tonne km, for pre NTS, post NTS and a hypothetical 'competitively neutral' situation. The externalities included accident costs, noise and air pollution and congestion costs. A summary of the BTE 'competitively neutral' external costs is given in Table 1 along with other estimates.

Table 1 Bureau of Transport Economics (Tasman Asia Pacific) externalities

Externality Measure	**Road (c/ntk)**		**Rail (c/ntk)**	
Noise pollution	0.034	(0.00)	0.018	(0.00)
Air pollution	0.01	(0.01 <)	0.004	(0.004 <)
Greenhouse gases	not specified			
Congestion costs	0.03	(0.03)	n.a.	(n.a.)
Enforcement costs	0.05	(0.05)	n.a.	(n.a.)
Accident Costs	0.32	(0.17)	0.03	(0.01)
Total	**0.444**	**(0.26)**	**0.052**	**(0.014)**

Reference: Bureau of Transport Economics (1999, Table iii.1 page 64) with Competitively Neutral data with road accident cost for six axle articulated trucks.
Tasman Asia Pacific (2000) Tables 7 and 9 as qualified by their text *is shown in brackets*

The rail accident cost of 0.03 cents per net tonne km was based on a BTE (1995) estimate of $69 million in 1993 for all rail systems, with further BTE assumptions including that of one third of the cost being due to freight, dividing by freight revenue ($2.7 billion in 1993) to get an accident rate per dollar of revenue of 0.852 per cent, and then using National Rail's 1997 freight revenue with adjustment for CPI.

For the allocation of noise costs due to heavy trucks powered by diesel, the BTE used data from the Inter-State Commission (ISC -1990, Vol 2 p 200). This was based on an earlier US Federal Highway Cost Allocation Study, suggesting A2.17 cents per km for rural hauls and A7.06 cents per km for urban hauls in 1989-90. Using an assumed East Coast urban share of 7 per cent, adjusted for CPI (1.20) and an average load of 20 tonnes, an average cost of 0.034 cents per net tkm was calculated. The average for rail was derived by the BTE on the basis that *"...rail carries 1.85 as much freight 'per noise' as road".*

To determine the environmental costs of air pollution, the BTE used data from the ISC (1990, Vol 2 p 203). Again, this was based on earlier US data, suggesting 0.016 cents per km for rural hauls using diesel and 2.357 cents per km for urban hauls in 1989-90. Using an assumed East Coast urban share of 7 per cent, adjusted for CPI (1.20) and an average load of 20 tonnes, the average cost of 0.01 cents per net tkm was determined. The average unit cost for rail was derived by the BTE using a road pollution figure per litre of diesel and then scaled for diesel use by rail.

As noted by the BTE (1999, p24), greenhouse gas costs *"...were not calculated because of the large degree of uncertainty associated with estimating both potential climate change and the costs associated with ameliorating or adapting to this change. Road, however, emits more than three times the greenhouse gases emitted by rail per unit of freight task ... "*

Within two years of the BTE (1999) estimates being published, four studies citing land freight external costs were undertaken. These were by Tasman Asia Pacific (2000), Booz.Allen and Hamilton (ARTC, 2001), Laird et al (2001), and the Bus Industry Confederation (BIC - 2001). In addition, Queensland Transport commissioned a study *Land Freight External Costs in Queensland* by this writer that was released by the Queensland Minister for Transport (Laird, 2003a). We look at these studies in turn.

A. Tasman Asia Pacific (2000), acting under instructions by the Australian Trucking Association, drew on the BTE study, and questioned many of the BTE assumptions. The summary results of Tasman Asia Pacific findings are given in Table 1.

B. As part of a National Interstate Track Audit commissioned by the Australian Rail Track Corporation (ARTC - 2001) Booz•Allen & Hamilton (Appendix A page 24) noted *'...six external cost items of noise pollution, air pollution, greenhouse gas emissions, congestion costs, accident costs, and incremental road damage costs'* and gave a Table of road and rail freight externalities. This Table (no 24) is repeated below as Table 2 and reflects the fact that estimates of noise, air pollution costs and congestion costs are higher in urban areas than in rural areas (as per BTE (1999) text but not BTE summary Tables).

C. Laird et al (2001) estimated the average unit cost for road crashes involving articulated trucks for 1997-98 at about 0.5 cents per net tkm in Australia. This was based on estimates for freight tasks, the numbers of fatal injuries and serious injuries (requiring hospitalisation) from both sources, with estimates of total costs using BTE (2000) 1996 estimates of $1.5 million for each fatal injury, $325,000 for each serious injury, and $12,000 as the average cost of other injuries. Estimates were also given for air pollution and noise costs due to all motor vehicle emissions at about $3 billion per annum.

Table 2 **Revised (and Track Audit) externality costs**

Externality		**Road (c/ntk)**		**Rail (c/ntk)**	
		QLD	**(TA)**	**QLD**	**(TA)**
Noise pollution	Rural	0.003	(0.003)	-	-
	Metro	0.006	(0.006)	0.004	(0.04)
Air pollution	Rural	-	-	-	-
	Metro	0.11	(0.11)	0.03	(0.03)
Greenhouse gases	Rural	0.17	(0.16)	0.064	(0.01)
	Metro	0.20	(0.16)	0.064	(0.01)
Congestion costs	Rural	-	-	-	-
	Metro	0.09	(0.09)	-	-
Accident Costs		0.50	(0.32)	0.03	(0.03)
Increased road maintenance		1.00	(0.64)	-	-
TOTALS	**Rural**	**1.673**	**(1.123)**	**0.094**	**(0.04)**
	Metro	**1.906**	**(1.326)**	**0.128**	**(0.074)**

Reference: QLD from Laird (2003a) (TA) from ARTC (2001) Appendix A, page 24, Table 24 with sources including Booz-Allen & Hamilton 1998 estimates, BTE (1999) and NRTC (1998)

D. A Bus Industry Confederation (BIC - 2001) submission to the Fuel Taxation Inquiry gave detailed estimates of a range of external costs. In regards to air pollution from motor vehicles in Australia, BIC estimated an annual cost of about $4.3 billion. This comprises $3.7 billion of costs imposed in capital cities, with about $0.6 billion in other urban areas. The cost of air pollution in all urban areas due to articulated truck movements was estimated at $342 million.

Estimates of the cost of noise from all motor vehicles in urban areas was given in a range of $0.7 to $1.9 billion per annum, with the cost of articulated truck movements in a range of $82 to $126 million per annum.

For greenhouse gas emissions, after consideration, the BIC considered the value of $A40 per tonne of carbon dioxide (CO2) *"...to be the current optimal level for carbon taxation. It is stressed this value is only relevant for the short-term; costs will increase dramatically in future years."* The use of the value of A$40/tCO2 gives a relevant charge level (carbon tax) of 10.7 cents per litre of diesel. With an assumed urban freight output of 33 tonne km per litre of diesel for articulated trucks, and 100 tonne km per litre of diesel for general freight trains, this gives 0.32 cents per ntkm for road haulage, and 0.11 cents per ntkm for rail haulage.

E. Taking into account the BTE (1999) and the four studies above, estimates were derived by this writer. These estimates appear in Table 2. The unit costs were used in a Brisbane - Townsville corridor report (The Straight Track Study) for Queensland Transport (Laird, 2003b), the NSW Department of Transport (2004) in a study of grain transport options, and, by Laird and Michell (2004) in analysis of Sydney - Melbourne rail upgrading options. These estimates are also noted by the Australasian Railway Association (ARA - 2005).

In addition to the above cited studies, Austroads (2000), BTE (2000), and the Fuel Taxation Inquiry (2001) consider external costs. The Australian Competition and Consumer Commission (2002, p114) notes that government funding to accommodate investment needs is *'potentially distorting in an efficiency sense'*, but that the investment may be justified provided that it passes a strict *"'global' cost benefit test; ie the total social benefits exceed the total social costs of the investment."*

1.1 More recent studies

In 2002, the Victorian Department of Infrastructure prepared Investment Appraisal and Evaluation Guidelines. A discussion of the complex issues involved in externalities was given by Pratt (2002) who concludes that *"… there is a heavy reliance on overseas data, which in some cases is dated or has been incorrectly transferred to Australian studies. Ongoing research and analysis is therefore needed for this area, not only to address the above factors, but because this issue is of increasing significance within Australia and internationally for implementation in project appraisal and evaluation."* This work cited various estimates of external costs, and some of these estimates are given in Table 3. As well, this research has been followed up within the BTRE (2004).

The BTRE (2003a) released a report on rail accident costs in Australia with new estimates, and a paper (BTRE, 2003b) giving new estimates of air pollution costs. In addition, a new range of estimates of costs of greenhouse gas emissions have emerged, ranging from about $10 per tonne of carbon dioxide equivalent (CSIRO etc, 2003) to $40 per tonne as used by the Victorian Department of Infrastructure (Pratt, 2002).

In addition, Austroads (2003) in updating an earlier study on external costs (Austroads, 2000) has drawn on two recent international studies. These are an INFRA/IWW (2000) study on behalf of the International Union of Railways; and an ExternE project for the European Commission.

Various Australian estimates for unit costs for road freight operations in metro areas are given in Table 3. As noted by the Austroads report (2003, p80). *"The valuation of the external costs of transport, in particular environmental externalities, is a complex and challenging area. Recent and current research around the world is progressing the state-of-the-art, which will enable environmental and social externality costs to be incorporated within an expanded project evaluation approach. … The average total air pollution unit costs for cars estimated in this document are of the order of 2 cents per vehicle-km, while the average estimated total environmental externality unit costs for cars are approaching 7 cents per vehicle-km. Similarly, those average estimated total unit costs for heavy vehicles are of the order of 4 cents per tonne km…"*

A discussion of road pricing for heavy trucks and external costs of land freight is also given by the BTRE (2003d). In addition, the 'Auslink' White Paper (Department of Transport and Regional Services - DOTARS, 2004a, p10) briefly discusses externalities *"…notably congestion, noise, and pollutant emissions—that occur almost exclusively in urban areas".* This was followed by the Australian Transport Council (ATC - 2004) with National Guidelines for Transport System Management in Australia that inter, alia, considered external costs with reference (Volume 2) to various default values for unit costs. Further discussion, with a range of unit external costs, is given by the ARA (2005).

The New Zealand Ministry of Transport (1996, 2005) has also undertaken various studies into external costs, the most recent being a detailed report on Surface Transport Costs and Charges. This report notes, inter alia, Auckland - Wellington external road freight accident costs at 1.1 cents per net tonne km.

Table 3 Selected road freight externality costs

	cents per tonne km				
Item	Austroads	Queensland	Victoria	ARA	ATC
Accidents	1.558	0.70	-	0.51	-
Air pollution (metro)	2.2	0.11	0.225	0.115	0.87
Noise (metro)	0.3	0.003	0.245	0.1	0.23
Greenhouse	0.4	0.2	0.268	0.155	0.07
Congestion	-	0.09	-	0.085	-

Reference: Austroads (2003), Table 4.1 estimated values for Heavy Duty Vehicles, where Greenhouse is noted as climate change; Queensland Transport (Laird, 2003a) Table 5.1 for metro values and Pratt (2002); for Victorian DOI with cents per vehicle km estimates divided by ABS (2003a) estimates of the average load of 20.39 tonnes in 2000 for articulated trucks in Victoria: ARA (2005, page 86). Medium values and ATC (2005 Vol.2 App.2) Default Externality Values.

2 Road and rail accident costs

Estimates of the total annual costs of accidents in Australia involving either articulated trucks or freight trains are gained from updated data from the Australian Transport Safety Bureau (ATSB) along with BTRE (2003a). The BTRE (2003a) estimated that the average economic cost of a fatality in a rail accident was $1.9 million in 1999 (as an 'average economic cost' as opposed to a 'willingness to pay' basis). This is an increase from the BTRE (2000) estimate of the cost of a road fatality in 1996 as $1.5 million. For the average cost of a road crash requiring hospitalisation, and the average cost of other (minor) injuries, the BTRE (2000) gave estimates of $325,000, and $12,000 respectively. By way of an overview, the ATSB (2003) gives data for each transport mode as in Table 4.

Table 4 Transport accident costs in Australia

Mode	*Cost $ million*	*Year*
Road	15,000	1996
Rail	113	1999
Marine	316	1993
Aviation	112	1996

Reference: ATSB (2003), pages 65, 67, 69 and 90. The estimate of the cost of road crashes is from the BTRE (2000) and noted as conservative by the ATSB and the cost of rail accidents is due to BTRE (2003a) and excludes suspected suicides and level crossing accidents involving motor vehicles.

Table 5 Fatalities involving articulated trucks

	On roads with speed limits exceeding 81 km/h	*On all roads*
1999	122	191
2000	151	208
2001	126	178
2002	142	200
2003	117	173
Totals	663	950

Reference: ATSB data base accessed via http://tssu.atsb.gov.au/disclaimer.cfm

2.1 Road freight accident costs

Extensive data for fatal road crashes involving articulated trucks and other vehicles in Australia is given by the ATSB. A very brief summary of some of the available data is given in Table 5. However, data from the ATSB for serious and other injuries due to road crashes involving articulated trucks is limited.

The Queensland Transport (Laird, 2003a) study noted that the average unit cost for road crashes involving articulated trucks over the five years to 2000 was 0.72 cents per net tkm. Using updated data including the BTRE (2003a) average economic cost of a fatality at $1.9 million and detailed Queensland road accident data; the average unit cost for road crashes involving articulated trucks over five years to 2003 in Queensland is 0.66 cents per net tkm, and, over this period 49 per cent of the cost of road crashes involving articulated trucks is due to fatalities.

As noted above, data from the ATSB for serious and other injuries due to road crashes involving articulated trucks is limited. From Table 5, 950 lives were claimed on Australian roads in road crashes involving articulated trucks over the five years to 2003. If we assume that say 50 per cent of the cost of road crashes involving articulated trucks in Australia is due to fatalities, and use the above cost of a fatality at $1.9 million, the total cost of these road crashes was $3610 million. The ABS (2004) estimates of the Australian freight task due to articulated trucks (ranging from 101 btkm in 1999 to 115.7 btkm 2003) show 529.1 btkm for the five years to 2003. Thus the average unit cost in the five years to 2003 for road crashes in Australia involving articulated trucks is about 0.68 cents per net tkm.

Clearly this is an area warranting better data and more research, and it would be appropriate to provide estimates for average accident costs involving articulated trucks for both urban and non - urban areas. In the absence of further data, it is proposed to use 0.6 cents per net tkm as an Australia wide average accident cost for freight moved by articulated trucks. This is about half way between older estimates of 0.5 cents per net tkm, and, the above findings.

It is of note that Austroads (2003, p75) found a derived road crash cost of $15.58 per 1000 tkm (ie 1.56 cents per net tkm) for road crashes involving articulated trucks. This was determined by noting that during 1996, a total of 193 fatalities involving articulated trucks formed 8.2 per cent of all road fatalities, then allocating this percentage to the BTRE (2000) estimate of the cost of all road crashes (inflation adjusted to 2000 values), and dividing by the articulated truck freight task.

2.1.1 National Highway System and Pacific Highway data

Some data supplied by the relevant State agencies in Queensland, New South Wales and Victoria for various parts of the National Highway System (NHS) within these states is given in Appendix B. In summary, the data shows that for the four years to 31 December 2003, 34 per cent of all fatalities in road accidents on the NHS (excluding the Federal and Barton highways) in these three states involved articulated trucks. This compares with articulated trucks being involved in 12 per cent of all fatalities of all road crashes in these three states.

The data in Appendix B also shows that in the 10 years to 31 December 2003, 36 per cent of all fatalities in road accidents on the NHS in NSW (again excluding the Federal and Barton highways) involved articulated trucks, and, 46 per cent of all fatalities in road accidents on the Newell Highway in NSW involved articulated trucks.

Additional data supplied by the NSW Roads and Traffic Authority shows that for the 10 years to 31 December 2003 and for road accidents on the Pacific Highway from Maitland to the Queensland Border, articulated trucks were involved in 30 per cent (163) of all fatalities (551); also, for the calendar year 2003 with road accidents on this highway, there were 72 fatalities, of which 23 involved articulated trucks. For non-urban sections of this highway, articulated trucks were involved in 36 per cent of all fatalities over this 10 year period, also for the calendar year 2003 with road accidents on the non-urban sections of this highway, there were 55 fatalities, of which 21 involved articulated trucks.

2.2 Rail freight accident costs

As noted above, a rail accident cost of 0.03 cents per net tonne km was based on a BTE (1995) estimate. In the absence of recent and sufficient Australia wide data, it is proposed to continue the use of this estimate. The following observations give some support to this value.

The cost of rail accidents was estimated by the BTRE (2003a) under one set of assumptions to be approximately $133 million in 1999. Costs were assigned to accidents involving all trains but excluded suicides and accidents at level crossings involving road vehicles. Most fatal rail accidents involved persons on or near rail track as opposed to train collisions or derailments. There was, however, no differentiation between accidents involving freight and passenger trains. However, if one assumes that 30 per cent of the $133 million is due to freight trains and uses a 1998-99 Australian rail freight task of about 127 billion tonne km, then an average rail freight accident cost of 0.031 cents per net tonne km is found.

Data relating to injuries for Queensland Rail freight operations, as provided by Queensland Transport for the five calendar years to 2000, shows that there were a total of 18 fatal injuries, 28 serious injuries and 59 other injuries from accidents involving freight trains. Using older BTRE data for the costs of road accidents, the accident cost for rail freight for these five years was $36.8 million. Using then published Queensland Rail freight task data over this period (150.9 billion tonne km) gives an average unit accident cost of 0.024 cents per net tonne km.

These estimates were updated in 2004 for the four calendar years to 2003, when there were a total of 14 fatal injuries, and other non fatal injuries from accidents involving freight trains. Using BTRE (2003a) costs for rail accidents, and their approach to exclude the cost of rail accidents at level crossings results in a cost of $24.3 million. Queensland Rail's published freight task to 30 June 2001 and extrapolated to over the next two financial years amounts to 154 billion tkm. This gives an average unit accident cost of 0.016 cents per net tonne km.

3 Environmental costs

3.1 Air pollution

Assigning unit values for the costs of air pollution from land freight movements in either metro or non-urban areas is problematic. Setting aside the question of whether a location is metro or non-urban, emissions and hence pollution cost per net tonne-kilometre will vary over time and with the location within a stated urban area. In almost all cases, B-Doubles will have a higher fuel efficiency and hence lower emissions per net tonne-kilometre than a six axle articulated truck.

In the case of rail freight, trains hauled in urban areas by electric locomotives using power generated in non-urban areas will produce appreciably less air pollution than trains hauled by diesel-electric locomotives. In urban areas, because the health effects of emissions from motor vehicles will vary with geography and weather conditions, there are also difficulties in making air pollution costs directly proportional to the quantity of a particular emission.

3.1.1 Articulated truck movements in urban areas

With these and other caveats, broad estimates are made for the costs of air pollution from articulated truck movements in urban areas. This will be from drawing on two reports of the BTRE (2005, 2003c). The BTRE (2005) Working paper updates BTRE (2003b) with the later paper giving a mid-range estimate of the annual health related costs from air pollution from motor vehicles in Australia's capital cities which was $2.33 billion for the year 2000. This comprises $1596 million from the estimated cost of mortality (premature death as a result of air pollution), and $735 million for morbidity (quality of life and/or productive capacity of victims impaired or reduced as a result of air pollution; and, this estimate is appreciably lower than the BTRE (2003b) estimate). Following Kunzli et al (2000), the BTRE (2003b and 2005) approach in part attributes air pollution costs to PM10 (particulate matter of size less than 10 microns) levels. The BTRE (2003c, Tables 3.9 and 3.116) report notes that the aggregate PM10 emissions from articulated trucks for Australian state capital cities in 2000 was 865 tonnes, and for all vehicles was 13,380 tonnes. This suggests that the health costs from air pollution on a PM10 basis due to the operation of articulated trucks in capital cities of $146.6 million. With articulated trucks hauling 996 million km during 2000 in Australia's state capital cities and having an average load of 22.62 tonnes (see Appendix A), a unit cost of 0.65 cents per net tonne km results.

It would be possible for articulated truck metro air pollution costs to be allocated on a fuel use basis. However, the use of the values based on PM10 emissions is recommended. As well, as intercity truck loads and bulk haulage loads are generally above average tonnages, metro truck loads are below average. For these two reasons, the estimates in health costs based on fuel use and cited above in cents per net tonne km will be conservative. We note also that the above $147m estimate is appreciably lower than the BIC annual estimate of $342m, also the Australian Transport Council (2005 Volume 2 Appendix 2) Default Externality Values include air pollution at 0.87 cents per net tonne km in urban areas as against the above 0.65 cents per net tonne km.

For air pollution in non-urban areas, we use a BTRE (2005) estimate of the total economic costs of motor vehicle related air pollution in regional areas of $332m, and a number of assumptions outlined in Appendix A that assign $113m of this cost to the operation of articulated trucks. Using ABS (2003) estimates for 2000 articulated truck aggregate distances in capital cities and throughout Australia, and the above average load, suggests an estimated unit cost of 0.13 cents per net tonne km.

3.1.2 Rail freight air pollution

When haulage by diesel - electric locomotives is used, we shall assume that the health costs from air pollution from rail freight are the same as those of road freight, modified by the overall ratio of fuel used for general rail freight haulage to road haulage by articulated trucks. Setting aside the very efficient rail haulage of iron ore in Western Australia, the ARA (2004, p22) notes the energy intensity for hire and reward heavy rail freight operations in 2001-02 as 0.31 net tonne kilometres per Megajoule (ntkm per MJ) on a Full Fuel Cycle (FFC) basis, and, the energy intensity for articulated trucks as 0.96 ntkm per MJ. This ratio is 3.097 to 1 is then set at the oft quoted factor of three to one.

On the basis of rail being three times more fuel efficient than articulated trucks, the health costs due to air pollution from rail freight in metro areas is 0.31 cents per tonne km on a PM10 basis in urban areas. For non-urban areas, the unit cost is 0.04 cents per tonne km.

3.2 Noise

The approach used by the BTRE (1999) to gain estimates of noise costs was based on an earlier US Federal Highway Cost Allocation Study as reported by the ISC (1990) which suggested A7.06 cents per km for urban hauls leading to an average cost of 0.034 cents per net tkm; also A2.17 cents per km for rural hauls giving a ratio of 3.25 to 1 whilst the average values for rail was derived by the BTE on the basis that *"...rail carries 1.85 as much freight 'per noise' as road".*

The estimates given by BIC (2001) for the cost of noise from all articulated truck movements were in a range of $82 to $126 million per annum. Taking the lower estimate along with articulated trucks being driven during 2000 in Australia's capital cities, an estimated 1.016 billion kilometres (BTRE, 2003) gives 8.07 cents per km. However, the Victorian Department of Infrastructure (Pratt, 2002) citing Stanley (BIC, 2001) and Delucchi and Hsu (1998) use a unit value of 5 cents per kilometre. We shall use this lower value. With an average load of 22.62 tonnes, a unit noise cost for articulated trucks of 0.22 cents per net tkm in urban areas in Australia is derived. The aggregate cost is $50.1 million.

Using the above cited ratios for noise costs, we obtain about 0.07 cents per net tkm for non-metro road haulage, 0.12 cents per net tkm for urban rail haulage, and 0.04 cents per net tkm for non-urban rail haulage. As proposed by BIC (2001) further research should be undertaken on noise costs from road traffic and on the most cost-effective means of reducing these costs. As well, further research should be undertaken on noise costs from rail freight.

3.3 Greenhouse gas costs

In regards to various estimates for the costs of greenhouse gas emissions, a mid-range value was used (Laird, 2003a) to derive unit costs was based on $25 per tonne of carbon dioxide equivalent (CO2e). The use of this value is supported by several writers (eg Quiggin (1998), and Common and Hamilton (1996)) and is similar to an earlier value of $NZ30 per CO2e tonne used by Transfund New Zealand (Austroads, 2000). For a conversion factor, we use Automotive Diesel Oil (ADO) emitting 69.70 grams of CO2 per MJ of end use energy (BTRE, 2002, p204), and 38.6 MJ per litre gives 2.69 kg of CO2 per litre of diesel. Then $25 per tonne equates to 6.725 cents per litre.

Using ABS (2003) data for 12 months ending 31 October 2002, an articulated road freight task in Australia of 106.98 billion tonne km (btkm) required the use of 2913 million litres of diesel. This gives an average of 36.72 tkm per litre. At 6.725 cents per litre, an average cost of 0.183 cents per net tonne km results for road freight moved by articulated trucks.

For rail freight, using the above one to three ratio, the unit figure is 0.06 cents per net tonne km.

It may be argued that a cost of $25 per tonne of CO2e is either too low, or too high. The BIC (2001) recommendation was for a tax of $40 per tonne of carbon dioxide, with their view that this estimate may prove to be conservative. As well, the Victorian Department of Infrastructure (Pratt, 2002) note overall unit prices in a range of $10 to $90 per tonne, and put $40 per tonne as a DOI 'Single Rate'. However, CSIRO, ABARE and BTRE (2003), have noted *"In the absence, at the present time, of an international market value for carbon dioxide equivalent emissions, the Australian Greenhouse Office has suggested use, on a illustrative basis, of the values contained in the 1999 publication, Discussion Paper 2 – Issuing the Permits (AGO, 1999b). The discussion paper postulated a permit price range of $10 to $50 a tonne CO2-e. The lower value of $10 a tonne CO2-e is consistent with the upper bound of the cost to government of abatement purchased under round 1 of the Greenhouse Gas Abatement Program (GGAP)."*

4 Road pricing for heavy trucks

In regards to unrecovered arterial road system costs from articulated truck operations on arterial roads, an average cost of 1.0 cent per net tonne km is proposed. This is based on an estimate (Laird et al, 2001) of an average for articulated truck operations on all roads as 1.25 cents per net tonne km and made use of: methodology similar to that used by an earlier NSW Commission of Inquiry into the Road Freight Industry; a unit cost of 7.45 cents per Equivalent Standard Axle (ESA) kilometre; and, relied on data published by the National Road Transport Commission (1998) as part of its Second Determination of Annual Heavy Vehicle Charges.

The National Transport Commission (NTC, 2004) is proceeding to a Third Determination of such charges, and at the time of writing was yet to publish the detailed data (vehicle kms, average gross mass kms, ESA kms etc) that is needed to recalculate road system costs attributable to the operation of the various types of heavy vehicles. A further change is that heavy vehicle charges are now adjusted each year by the NTC. This is by way of a complex formula that takes into account road construction costs (rural and urban, arterial and local) and is constrained by no decrease in charges from year to year and capped by CPI increases. Accordingly, the earlier values of under-recovery are used.

The issue of road pricing for heavy trucks is expected to receive increasing attention. The ARA's (2004b) infrastructure policy, inter alia, called on Government to *"review infrastructure funding and access pricing methodologies to remove inequities between road and rail…"* The Australian Trucking Association (2004, p 14) maintains that *"The industry more than pays for its attributed share of road costs"* whilst the Australian Financial Review (2004) notes, inter alia, that full cost recovery from trucks *"… would probably require the commonwealth and state governments to brave a deafening blockade of their respective parliament houses."*

The BTRE (2003d, page 2 of summary), also NTC (2004, p60), suggested that with present arrangements the heaviest vehicles achieve only 90 per cent recovery whilst there is over-recovery of costs from rigid trucks and *"Current heavy vehicle infrastructure pricing arrangements achieve the objective of recovery of aggregate attributed costs, including capital costs (108 per cent)."* However, this finding is not supported by earlier work of the Bureau of Transport Economics (BTE -1988) that found during 1985-86, articulated truck operations had a resultant under-recovery of road system costs of $1283 million.

A more balanced position was given by the BTE (1999, page xi) as follows *"Under the current road user charging system, trucks overall are undercharged for their use of the road system. Moreover, larger more heavily laden vehicles and those travelling larger distances are charged the least (per tonne kilometre) while smaller, less heavily laden vehicles and those travelling shorter distances cross-subsidise them."* The BTE (1999, p 58) also suggested that *"Mass-distance based road use charges offer greater scope to reflect the avoidable cost of heavy vehicle road use."*

It is doubtful if the NTC in its third determination will use either mass differentiation or distance differentiation in its annual charges for heavy vehicles. Moreover, the third determination of charges will exclude external costs. In this regard, the BTRE (2003d - page 3 of summary) notes: *"There is no charging for externalities in either mode … while externalities are lower for rail freight than for road freight, it would generally not be appropriate to charge heavy road vehicles (and/or freight trains) and exclude light vehicles (and/or passenger trains)."*

5 Proposed Australian external costs

Even if the users of land freight transport are not required to meet their full external costs, such costs should be fully accounted for when major infrastructure investment decisions are being made. Based on the information in this report, the following values in Table 6 are recommended as year 2000 values. It may be noted that excluding unrecovered road system costs, the metro articulated truck road external cost of 1.75 cents per net tonne km is less than half of the approximate value cited by Austroads (2003) of about 4 cents per net tonne km.

It is of note that road vehicle operators using petrol pay an appropriate de facto externalities charge through fuel excise without rebates, also the assigned average health costs from car use (1.3 cents per km) in the state capital cities equates to about 12 cents per litre of petrol used. However, following introduction of the New Tax System in 2000, the operators of heavy vehicles were granted conditional rebates for the use of diesel, which have since been further extended to effectively require no payment of external costs (cf about 20 cents per litre prior to 2000).

Table 6 Recommended revised Australian land freight externality costs (2000)

Externality Measure	Road (c/ntk)	Rail (c/ntk)
Accident Costs	0.60	0.03
Air pollution		
- Metro	0.65	0.22
- Rural	0.13	0.04
Noise pollution		
- Metro	0.22	0.12
- Rural	0.07	0.04
Greenhouse gases	0.18	0.06
Congestion (Metro only)	0.10	-
Increased road maintenance	1.00	
TOTALS		
Metro	**2.75**	**0.43**
Rural	**1.98**	**0.17**

Reference: As per text. Note that road maintenance costs for roads of light construction are higher, also that any rail track subsidies may need to be taken into account.

Further work is required in the area of land freight external costs. However, this should not stop government now incorporating into road user pricing and rail pricing conservative values for external land freight costs, so that the operators of diesel powered road vehicles and trains pay a basic externalities charge. This charge could be a adjusted following refinement of the initial estimates. It is also recommended that the additional revenue generated be applied to long overdue land transport infrastructure upgrades (see, for example, Kilsby et al, 2004).

In addition, more work is required in the area of land passenger transport external costs.

Acknowledgements

The author thanks Queensland Transport and the CRC for Railway Engineering and Technologies. He is also grateful for the research assistance of Ms G De Battista of the School of Mathematics and Applied Statistics of the University of Wollongong and an unknown referee for comments on the paper.

However, the research findings and results of this paper along with the Smooth Running Study, the Straight Track Study and Land Freight External Cost Study are not necessarily endorsed by Queensland Transport or other agencies.

Appendix A Metro vehicle use and health costs - PM 10 basis

This Appendix gives Bureau of Transport and Regional Economics (BTRE, 2003c) estimates of vehicle use and PM 10 emissions for the year 2000 in Australia's metro areas from various classes of motor vehicles (cars, Light Commercial Vehicles (LCVs), rigid trucks, articulated trucks, buses and Motorcycles (MCs)) for each capital city. These are summarised in Table A.1. The BTRE (2003b) estimates of health costs air pollution costs are given in Table A.2 along with estimates of PM 10 emissions.

Table A.1 Estimates of metro vehicle kilometres

billion vehicle kilometers in the year 2000

City	Cars	LCVs	Rigid Trucks	Artic. Trucks	Buses	MCs	Total
Sydney	28.93	5.73	1.38	0.326	0.250	0.27	36.89
Melbourne	28.09	3.56	1.04	0.293	0.177	0.17	33.33
Brisbane	11.29	2.28	0.47	0.141	0.122	0.17	14.47
Adelaide	8.21	1.16	0.23	0.078	0.077	0.06	9.84
Perth	9.97	2.2	0.41	0.143	0.097	0.07	12.81
Hobart	1.39	0.22	0.08	0.015	0.021	0.01	1.74
Darwin	0.55	0.2	0.05	0.014	0.018	0.01	0.85
Canberra	2.82	0.52	0.06	0.006	0.026	0.03	3.2
All Capitals	91.24	15.88	3.73	1.016	0.788	0.79	113.4

Reference: BTRE (2003c) Tables 1.36 to 1.41 inclusive. LCV = Light commercial vehicle

Table A.2 Estimates of health costs and metro PM10 emissions

City	Health costs ($m)	Thousands of tonnes of PM10 in the year 2000 Cars	LCVs	Rigid Trucks	Artic. Trucks	Buses	TOTAL
Sydney	1036	2.135	0.888	1.048	0.277	0.275	4.64
Melbourne	658	2.078	0.553	0.823	0.249	0.194	3.91
Brisbane	295	0.826	0.349	0.367	0.12	0.134	1.81
Adelaide	162	0.617	0.182	0.191	0.072	0.084	1.15
Perth	153	0.74	0.343	0.314	0.134	0.107	1.64
Hobart	11	0.1	0.033	0.061	0.013	0.022	0.23
Darwin	7	0.039	0.031	0.034	0.013	0.02	0.14
Canberra	8	0.201	0.083	0.046	0.005	0.029	0.36
All Capital Cities	2330	6.737	2.462	2.885	0.883	0.865	13.88

Reference: BTRE (2005) Table 6.10 for health costs, and for PM10 emissions BTRE (2003c) Tables 3.9, 3.53,3.75, 3.97, 3.116 and 3.136

The data in Table A.3 is found by apportioning the health costs on the basis of PM 10 emissions in each State capital city for each class of vehicle in Table A.2 and then dividing by the relevant estimate of vehicle kilometres in Table 1. It is of note that the assigned average cost of health costs from car use in the state capital cities is 1.3 cents per kilometre. At an average fuel use of 11.3 litres of petrol per 100 km in the year 2000 (ABS, 2003), this equates to an external cost equivalent to about 12 cents per litre of petrol.

Table A.4 gives various average load data for road freight vehicles and estimates of metro air pollution costs.

Table A.5 gives estimates of fuel use in Australia and its capital cities for various classes of motor vehicles, also ratios between metro fuel use and PM10 emissions. These are used in Table A.6 to allocate air pollution costs in regional areas.

Table A.3 Estimates of health costs from metro fuel use apportioned by PM 10 emissions

cents per vkm in the year 2000

City	Cars	LCVs	Rigid Trucks	Artic. Trucks	Buses
Sydney	1.6	3.5	17.0	19.0	24.6
Melbourne	1.2	2.6	13.3	14.3	18.4
Brisbane	1.2	2.5	12.7	13.9	18.0
Adelaide	1.1	2.2	11.7	13.0	15.4
Perth	0.7	1.5	7.1	8.7	10.3
Hobart	0.3	0.7	3.6	4.1	5.3
Average of State Capital Cities	1.3	2.7	13.6	14.7	18.7

Reference: Using Tables A.1 and A.2

Table A.4 Estimates of average loads and unit health costs apportioned by PM 10 emissions

	Average load carried (tonnes)			Unit health costs cents per ntkm		
	LCVs	Rigid Trucks	Artic. Trucks	LCVs	Rigid Trucks	Artic. Trucks
Sydney	0.35	4.79	21.64	9.9	3.5	0.9
Melbourne	0.4	6.77	20.39	6.5	2.0	0.7
Brisbane	0.39	6.64	23.34	6.4	1.9	0.6
Adelaide	0.36	6.25	23.26	6.1	1.9	0.6
Perth	0.38	5.67	28.16	3.8	1.3	0.3
Hobart	0.39	5.42	23.75	1.8	0.7	0.2
Australia	0.38	5.85	22.62	7.1	2.3	0.65

Reference: ABS (2003, Table 16) for 2000 for average load carried for each State, and use of Table A.3.

Table A.5 Fuel use by class of vehicle and area etc

	Cars etc	LCVs	Rigid T	Artic T	Buses
Overall fuel use (billions of litres)					
Petrol	14.2	2.19	0.04		0.02
Diesel	0.67	0.95	1.72	2.9	0.44
LPG etc	np	0.58	0.04	-	0.01
Total	16.84	3.72	1.8	2.9	0.47
Urban fuel use	10.66	2.14	1.04	0.51	0.21
PM10 (000's of tonnes)	6.74	2.46	2.88	0.88	0.86
Ratio	0.63	1.15	2.77	1.73	4.10

Reference: ABS (2003, Table 16) for overall fuel use for 12 months to October 2000, BTRE (2003b) Tables 2.31 to 2.36 for urban (capital city) fuel use. For cars, LCVs and MCs, fuel used is in gasoline equivalents, whilst for trucks and buses, fuel used is diesel equivalents. The total includes 0.07 billion litres of fuel for motor cycles. PM10 emissions are from Tables 3.9, 3.53,3.75, 3.97, 3.116 and 3.136 BTRE (2003b)

Table A.6 Regional health costs by class of vehicle

Fuel use in billions of litres, PM10 Cost Allocation in millions of dollars

	Cars etc	LCVs	Rigid T	Artic. T	Buses
Regional fuel use	6.18	1.58	0.76	2.39	0.26
Adjusted for ratio	3.91	1.82	2.10	4.12	1.06
Percentage	32	15	17	34	9
PM10 Cost Allocation	107	50	58	113	29

Reference: Regional fuel use from Table A.5 (overall less urban), the ratio being that of PM10 emissions to fuel use from Table A.5, Percentage as for PM10 emissions, with PM10 Cost Allocation based on the base case total of $332 million (BTRE, 2005, Table 6.11, p101).

Appendix B National Highway System accident data

Some data supplied by the relevant State agencies in Queensland, New South Wales and Victoria for various parts of the National Highway System (NHS) within these states is given in Table B1. A description of various sections of the NHS is given by (DOTARS, 2004b).

Table B1 Fatalities involving all vehicles and articulated trucks

All Vehicles	National Highway System				All of state			
	Qld	NSW	Vic	total	Qld	NSW	Vic	total
2000	83	54	28	165	317	603	407	1327
2001	74	53	32	159	324	524	444	1292
2002	64	54	33	151	322	561	397	1280
2003	49	43	29	121	310	539	330	1179
Total	270	204	122	596	1273	2227	1578	5078
Involving Articulated Trucks								
2000	29	32	10	71	40	84	40	164
2001	18	16	8	42	33	60	48	141
2002	18	25	8	51	28	86	49	163
2003	11	13	15	39	35	63	41	139
Subtotal	76	86	41	203	136	293	178	607
per cent of total	*28.1*	*42.1*	*33.6*	*34*	*10.7*	*13.2*	*11.3*	*12*

Reference: Data kindly supplied by Queensland Transport, NSW Roads and Traffic Authority, and Vic Roads.

Table B2 (part) NSW Fatalities involving all vehicles and articulated trucks
All vehicles

	Hume	NewEngland	Syd N'ctle	Newell	Sturt	All NHS	Total NSW
1994	26	15	7	25	8	81	647
1995	26	22	6	11	6	71	620
1996	19	19	7	4	1	50	581
1997	26	15	7	17	4	69	576
1998	25	25	8	14	1	73	556
1999	27	21	6	18	3	75	578
2000	13	18	5	15	3	54	603
2001	18	14	9	11	1	53	524
2002	21	8	7	17	1	54	561
2003	14	14	5	5	5	43	539
Total	215	171	67	137	33	623	5785

Table B2 (continued) NSW Fatalities involving all vehicles and articulated trucks

Involving Articulated Trucks

	Hume	NewEngland	Syd N'ctle	Newell	Sturt	All NHS	Total NSW
1994	12	2	1	10	4	29	67
1995	3	8	0	6	2	19	63
1996	5	10	3	2	0	20	56
1997	8	4	1	13	1	27	71
1998	12	7	3	1	1	24	71
1999	3	9	2	5	0	19	64
2000	9	9	2	9	3	32	84
2001	3	5	3	4	1	16	60
2002	11	1	2	11	0	25	86
2003	5	3	2	2	1	13	63
Subtotal	71	58	19	63	13	224	685
% of Total	*33*	*33.9*	*28.4*	*46*	*39.4*	*36*	*11.8*

Reference: Data kindly supplied by the NSW Roads and Traffic Authority.

References

Abelson (1986) *The Economic Evaluation of Roads in Australia*, Sydney

Australian Bureau of Statistics
- (2003) *Survey of Motor Vehicle Usage for 12 months ended 31 Oct 2002*
- (2004) *Survey of Motor Vehicle Usage for 12 months ended 31 Oct 2003*

Australian Competition and Consumer Commission (2002) Decision re Australian Rail Track Corporation Access Undertaking

Australian Financial Review (2004) *Rail plan needs political will* editorial for 18 August 2004

Australian Rail Track Corporation (2001) *National Track Audit*

Australasian Railway Association
- (2004a) *Australian Rail Industry Report:2003*
- (2004b) *Infrastructure Investment Policy; Investing for the future*
- (2005) *The future for freight* report by Port Jackson Partners Ltd

Australian Transport Council (2004) *National Guidelines for Transport System Management In Australia*.

Australian Trucking Association (2004) *Trucking - driving Australia's growth and prosperity*

Australian Transport Safety Bureau (2003) *Annual Review 2003*

Austroads, Sydney
- (2000) *Australia Valuing emissions and other externalities: A brief review of recent studies*
- (2003) *Valuing Environmental and Other Externalities*
- (1996) *Benefit cost manual*

Brindle R, Houghton N and Sheridan G (1999), *Transport-generated air pollution and its health impacts*, ARRB Transport Research

Bureau of Transport and Regional Economics
- (1988) *Review of Road Cost Recovery*
- (1995) *Information Sheets 4 ,5, 7 and 8*
- (1999) *Competitive neutrality between road and rail* Working Paper No 40
- (2000) *The cost of road crashes*
- (2002) *Greenhouse emissions from transport - Australian trends to 2020*
- (2003a) *Rail accident costs in Australia*
- (2003b) *The economic consequences of the health effects of transport emissions in Australian capital cities*, paper by J Amoaka et al to the ATRF, Wellington
- (2003c) *Urban pollutant emissions from motor vehicles: Australian trends to 2020*
- (2003d) *Land transport infrastructure pricing: an introduction*, Working Paper 57
- (2004) *Externalities and inter-capital freight transport* scoping report
- (2005) *Health Impacts of transport emissions in Australia: Economic costs* WP 63

Bus Industry Confederation (2001) *Getting the Prices Right: Policy for More Sustainable Fuel Taxation for Road Transport in Australia* Submission (by Mr John Stanley) to the Commonwealth Fuel Taxation Inquiry.

CSIRO, ABARE and BTRE (2003) *Appropriateness of a 350 million litre biofuels target*

Common M and Hamilton C (1996) The economic consequences of carbon taxation in Australia' in Bouma W J, Pearman G I, and Manning M (eds) Greenhouse: C*oping with Climate Change,* CSIRO Publishing, Melbourne

Department of Transport and Regional Services
- (2004a) '*Auslink' White Paper*
- (2004b) website www.dotars.gov.au

Delucchi, M and Hsu, S (1998) The External Damage Cost of Noise Emitted from Motor Vehicles, Journal of Transportation and Statistics, October

Fuel Taxation Inquiry (2001) *Issues paper*

Infras/IWW (2000) *External Costs of Transports – Accident, Environmental and Congestion Costs in Western Europe*, Zurich and Karlsruhe

Inter-State Commission (1990) *Road Use Charges and Vehicle Registration: A National Scheme*

Kilsby D Laird P and Bowers D (2004) *Australian Transport Infrastructure: Fit For Purpose?* Australasian Transport Research Forum, Adelaide

Kunzli N Kaiser R and Medina S (2000) Public health impact of outdoor and traffic related air pollution: a European assessment, *Lancet* Vol 356, Sept 2 2000.

Laird P and Michell M (2004) *Interstate rail track upgrading options to 2014* Australasian Transport Research Forum, Adelaide

Laird P Newman P Bachels M and Kenworthy J (2001) *Back on Track: Rethinking transport policy in Australia and New Zealand* UNSW Press.

Laird P (released 2003 by Queensland Transport, Brisbane)
- (2003a) *Rail Studies: Land Freight External Costs in Queensland*
- (2003b) *Rail Studies: The straight track study*

Manins P (1997) Transport: *The future is clearer'* Paper presented at Outlook '97, Canberra

National Road Transport Commission (1998) *Updating heavy vehicle charges*

National Transport Commission (2004) *Impediments to improving efficiency in the area of intermodal transport* draft policy paper

National Transport Planning Taskforce (1994) *Building for the Job* (Main report)

New South Wales Department of Transport (2004) Grain Infrastructure Advisory Council report

New Zealand Ministry of Transport, Wellington
- (1996) *Land Transport Pricing Study, Environmental Externalities*
- (2005) *Surface Transport Costs and Charges*

Pratt C (2002) Estimation and valuation of environmental and social externalities for the transport sector Australasian Transport Research Forum, Canberra

Quiggin J (1998) *Taxing times: A guide to Australia's tax debate*, UNSW Press

Simpson R and London J (1995) *An economic evaluation of the health impacts, of air pollution in the BCC area*, Report to the Brisbane City Council

Tasman Asia Pacific (2000) *Competitively Neutral Freight Rates for Road and Rail*, report prepared for the Australian Trucking Association.

Victoria Environmental Protection Authority (1994) *Victorian Transport Externalities Study*

Victorian Department of Infrastructure (1994) *Investment appraisal guidelines*